Claims

1. A stress microsensor designed to be incorporated between two mechanical elements of a kinematic chain and comprising two parallel flat faces, one of which, called the fixed face (102), is designed to be connected to a first mechanical element such as a support and the other, called the moving face (103), is designed to be connected to a second mechanical element such as a tool, and comprising, between these two faces (102, 103), a stress-measuring assembly including at least one micromachined layer and adapted to supply an electronic signal representing a stress applied between the moving face (103) and the fixed face (102), wherein:

- the fixed face (102) is firmly joined to a first block of micromachined silicon, called the fixed block (104),
- the moving face (103) is firmly joined to a second block of micromachined silicon, called the moving block (106),
- clearance is provided between the fixed (104) and mobile (106) blocks so as to allow relative translational displacement of these blocks (104, 106) in at least one direction, called the shear displacement direction, parallel to the fixed (102) and moving (103) faces,
- the fixed (104) and moving (106) blocks are connected to one another by means of a restoring device (108) of micromachined elastically deformable silicon under the effect of relative displacement of the blocks (104, 106) in said shear displacement direction,

- it includes an assembly (113a, 113b, 114a, 114b, 117a, 117b, 122a, 122b) for measuring relative displacements of the blocks in said shear displacement direction that is able to supply a signal representing these displacements and therefore representing the shear stress applied between the moving face (103) and the fixed face (102).

2. The microsensor as claimed in claim 1, wherein:
- clearance is provided between the fixed (104) and moving (106) blocks so as to allow relative translational displacement of these blocks in all shear displacement directions,
- the restoring device (108) is elastically deformable under the effect of relative displacement of the blocks in all shear displacement directions,
- the measuring assembly (113a, 113b, 114a, 114b, 117a, 117b, 122a, 122b) is adapted to measure relative displacements of the blocks (104, 106) in all shear displacement directions and is able to supply a signal representing these displacements and therefore representing the corresponding shear stress applied between the moving face (103) and fixed face (102).

3. The microsensor as claimed in either of claims 1 and 2, wherein:
- clearance is provided between the fixed (104) and moving (106) blocks so as to allow relative translational displacement of these blocks (104, 106) in at least one direction, called the pressure direction, normal to the fixed (102) and moving (103) faces,

- the restoring device (108) is elastically deformable under the effect of relative displacement of the blocks (104, 106) in each pressure direction,
- it includes a measuring assembly (118, 119) adapted to measuring relative displacements of the blocks in each pressure direction and able to supply a signal representing these displacements and therefore representing the pressure stress applied between the moving face (103) and the fixed face (102).

4. The microsensor as claimed in any one of claims 1 to 3, wherein the measuring assembly (113a, 113b, 114a, 114b, 117a, 117b, 122a, 122b) is of the capacitive type and includes at least one electrode, called the fixed electrode (113a, 113b, 114a, 114b), firmly joined to the fixed block (104) and at least one electrode, called the moving electrode (117a, 117b, 122a, 122b), firmly joined to the moving block (106), the electrodes being arranged opposite one another so as to form between them a capacitance the value of which varies during relative displacements of the blocks (104, 106) in the shear directions.

5. The microsensor as claimed in claim 4, wherein each electrode of a pair of opposed fixed (113a, 113b, 114a, 114b) and moving (117a, 117b, 122a, 122b) electrodes is formed by a comb of strips of conductive material extending parallel to one another and to the fixed (102) and moving (103) faces, and extending orthogonally to a shear direction in which this pair of electrodes allows the relative displacements of the blocks (104, 106) to be measured.

6. The microsensor as claimed in claim 5, wherein it includes at least one first pair of electrodes (113a, 113b, 117a, 117b) adapted to detect relative displacements along a first shear axis (x) and at least one second pair of electrodes (114a, 114b, 122a, 122b) adapted to detect relative displacements along a second shear axis (y) perpendicular to the first shear axis (x).

7. The microsensor as claimed in any one of claims 1 to 6, wherein the fixed block (104) includes at least one rectangular recess (105) for receiving the rectangular moving block (106), and wherein it includes four corner elbow levers (108) of micromachined silicon that are elastic in deflection, each elbow lever (108) having one end connected to a side wall of the recess (105) and another end connected to a side wall of the moving block (106) orthogonal to said side wall of the recess (105), so that this elbow lever (108) is interposed between a corner of the recess (105) and an opposed corner of the moving block (106) and is able to be deformed elastically in deflection when the moving block (106) is displaced in a shear direction with respect to the recess (105).

8. An end tool of a surgical instrument comprising:
- at least one tool-holder support (1, 50) made of a rigid material including a flat face, called the base layer (2, 51), adapted to support a tool,
- at least one surgical tool (11, 60) composed of a stack of elementary layers firmly joined to one another so as to form a functional tool unit fixed to the base layer (2, 51) of the tool-holder support, and

including at least one layer forming a stress microsensor and a functional end layer (33, 70) having a form designed to ensure the operation of the tool, wherein the surgical tool includes at least one stress microsensor (100) as claimed in any one of claims 1 to 7.

9. The end tool as claimed in claim 8, wherein said surgical tool also includes at least one micromachined layer, called the electronic layer (20), incorporating a connector for connection to an electronic and/or light and/or fluid power source, and at least one electronic function for signal processing and/or measurement and/or actuation and/or power supply.

10. The end tool as claimed in either of claims 8 and 9, wherein the surgical tool (11; 60) includes a support layer (12; 61) designed to be fixed to the base layer (2; 51) of the tool-holder support (1; 50) and including a connector (14) for connection, firstly, to the connector of each electronic layer and, secondly, to an electrical and/or light and/or fluid power source.

11. The end tool as claimed in any one of claims 8 to 10, wherein the surgical tool (11; 60) includes an interface layer (30; 66) adapted to be firmly attached below the functional layer (33; 70) and incorporating components (31, 32; 67, 68) for energy transfer between the external medium and the electronic layer.

12. The end tool as claimed in any one of claims 8 to 11, wherein the surgical instrument (11; 60) includes pins

(40) extending through superposed openings formed in the different layers of said tool and designed to be fixed into openings (7; 55) formed in the base layer (2; 51) of the tool-holder support (1; 50).

13. The end tool as claimed in any one of claims 8 to 12, wherein it consists of a forceps formed by two tool-holder support/surgical instrument assemblies (1, 11, 1', 11'), the tool-holder supports (1, 1') of which are each provided on a prolongation of their base layer (2, 2') with a lug (4, 4') orthogonal to said base layer for the articulation of the forceps.

14. The end tool as claimed in claims 11 and 13, wherein the functional layer (33) of each surgical tool incorporates at least one electrode (34, 35) flush with the upper face of said functional layer, the interface layer (30) including a conductive component (32) for supplying each electrode with energy.

15. The end tool as claimed in any one of claims 8 to 12, wherein it consists of a bistoury having one blade or a scissors blade including a functional layer (70) in the form of a blade having a longitudinal side face with a beveled profile forming a longitudinal cutting edge.

16. The end tool as claimed in claims 11 and 15, wherein the functional layer (70) forms a bipolar blade provided with a thickness (72) made of electrically conductive material, the interface layer (66) including a conductive component (67) for supplying said conductive thickness with energy.